**OXFORD**
*Revise*

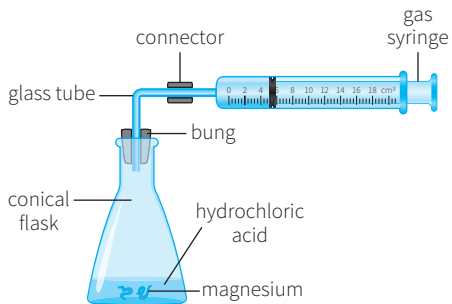| Question | Answers | Extra information | Mark | AO Spec reference |
|---|---|---|---|---|
| **1(a)(i)** | zero | | 1 | 5.1.1 AO1 |
| **1(a)(ii)** | $4.3 \times 10^{-3} = k \times 0.38^2$ <br> $k = 0.0297(7)$ <br> $mol^{-1}\,dm^3\,s^{-1}$ | Allow answers rounded to 0.030 | 1 <br> 1 <br> 1 | 5.1.1 AO2 MS0.0, 2.4 |
| **1(b)** | $T = 298K$ <br> $\ln 0.02977 = \dfrac{-E_a}{(8.31 \times 298)} + 19.8$ <br> $E_a = 57700$ J mol$^{-1}$ or 75.7 kJ mol$^{-1}$ | Allow e.c.f. for ans from 01.2 <br><br> Must be positive. Allow answer that rounds to 57700 J mol$^{-1}$ or 57.7 <br> Allow any row of data from table <br> Final mark for consistent units | 1 <br> 1 <br> 1 <br> 1 | 5.1.1 AO2 Ms3.3, 3.4 |
| **1(c)** | Mechanism 1 <br> Because Y is not in the rate equation/ Y is zero order / two X molecules are required/used | | 1 <br> 1 | 5.1.1 AO3 |
| **2(a)** | Second order | | 1 | 5.1.1 AO2 |
| **2(b)** | First order | | 1 | 5.1.1 AO2 |
| **2(c)** | rate $= k\,[A][B]^2$ <br> $2.50 \times 10^{-3} = k \times 5 \times 1^2$ <br> $k = 5.00 \times 10^{-4}$ <br> $mol^{-2}dm^6s^{-1}$ | | 1 <br> 1 <br> 1 <br> 1 | 5.1.1 AO2 MS0.0,2.2 |

| Question | Answers | Extra information | Mark | AO Spec reference |
|---|---|---|---|---|
| 3(a)(i) | First | | 1 | 5.1.1 AO2 |
| 3(a)(ii) | First | | 1 | 5.1.1 AO2 |
| 3(a)(iii) | Zero | | 1 | 5.1.1 AO2 |
| 3(a)(iv) | Rate $= k$ $[X][Y]$<br><br>$k = \dfrac{\text{rate}}{[X][Y]} = \dfrac{7.5 \times 10^{-3}}{1 \times 10^{-3} \times 1 \times 10^{-3}}$<br><br>$k = 7500$<br>$mol^{-1}\,dm^3\,s^{-1}$ | Allow any row of data from table | 1<br><br>1<br><br>1<br>1 | 5.1.1 AO2 MS0.0,2.2 |
| 3(b)(i) | $K_c = \dfrac{[D][E]}{[X][Y]^2[Z]}$<br>Moles at equilibrium:<br>X = 0.90<br>Y = 0.80<br>Z = 0.20<br>D = 0.60<br>E = 0.60<br>$K_c = \dfrac{0.60 \times 0.60}{0.90 \times 0.80^2 \times 0.20}$<br><br>$= 3.125$<br>$mol^{-2}\,dm^6$ | | 1<br><br><br><br><br><br><br>1<br><br><br>1<br>1 | 3.2.3 AO2 Ms2.2,2.3 |
| 3(b)(ii) | $K_c$ will be smaller<br>Equilibrium will shift left /towards endothermic<br>So denominator will be larger | | 1<br>1<br>1 | 3.2.3 AO3 |

**OXFORD Revise**

| Question | Answers | Extra information | Mark | AO Spec reference |
|---|---|---|---|---|
| **4(a)** | Appropriate tangent drawn<br>Appropriate gradient calculated | Should touch the curve at 50s and be at least 4 cm long | 1<br>1 | 5.1.1<br>Ms3.3,3.4<br>AO3 |
| **4(b)** | Appropriate diagram of gas syringe and conical flask<br>Similar to<br><br>Correct labels of equipment | Can be test tube<br><br>Check all connections are complete and no tubes are cut off by pen lines<br><br>Ignore clamp stand<br><br>Ignore timer/ measuring cylinder, etc.<br><br>Allow equivalent diagram for collecting gas over water | 1<br><br><br><br>1 | 5.1.1<br>AO3 |
| **4(c)(i)** | $1.9/24.3 = 0.078$<br>Moles of $HCl = 2 \times 0.100 = 0.200$ moles<br>Evidence of ratio/balanced equation<br>Moles of $H_2 = 0.078$ | | 1<br>1<br><br>1 | 2.1.3<br>MS0.1,0.2<br>AO2 |
| **4(c)(ii)** | Moles of $HCl$ left $= 0.200 - (2 \times 0.078) = 0.044$<br>$[H^+] = 0.044/0.1 = 0.44$<br>$pH = -\log(0.44)$<br>$= 0.36$ | Allow e.c.f. from **4(c)(i)**<br><br>1.36 scores **3** marks<br>Must be 2dp | 1<br>1<br>1<br>1 | 5.1.3<br>MS0.4, MS2.5<br>AO2 |

| Question | Answers | Extra information | Mark | AO Spec reference |
|---|---|---|---|---|
| 5(a)(i) | See table below | | 2 | 5.1.1 AO3 MS 3.1 |

| Expt. | Volume of KI(aq) (cm³) | $\log_{10}$ (volume of KI(aq)) | Time (s) | $\log_{10}\left(\dfrac{1}{t}\right)$ |
|---|---|---|---|---|
| 1 | 10 | **1.00** | 142 | −2.15 |
| 2 | 16 | **1.20** | 92 | −1.96 |
| 3 | 20 | **1.30** | 64 | −1.81 |
| 4 | 30 | **1.48** | 50 | −1.70 |
| 5 | 40 | **1.60** | 40 | −1.60 |
| 6 | 50 | **1.70** | 28 | −1.44 |

| Question | Answers | Extra information | Mark | AO Spec reference |
|---|---|---|---|---|
| | Log (1 / time) on the $y$-axis + log (vol) on $x$-axis<br>Sensible scales<br>Plots points correctly ± one square<br>Line of best fit correctly drawn | | 1<br>1<br>1<br>1 | |
| 5(a)(ii) | Reads appropriate points from graph showing working or triangle<br>Gradient = 0.96 +/− 0.02<br>Answer to 2 d.p.<br>First order reaction | Allow points from data table | 1<br>1<br>1<br>1 | 5.1.1 AO3 MS 3.1 |
| 5(b) | Colorimeter / UV-visible spectrometer / light sensor to monitor colour change<br>Because eliminates human error in timing / more accurate time of colour change | | 1<br>1 | 5.1.1 AO3 |

| Question | Answers | Extra information | Mark | AO Spec reference |
|---|---|---|---|---|
| 6(a) | Substance that increases the rate of reaction by providing an alternative route<br>Which are not used up in the reaction | | 1<br><br>1 | 3.2.2<br>AO1 |
| 6(b)(i) | Propanone = first<br>Iodine = zero<br>Acid = first | | 1<br>1<br>1 | 5.1.1<br>AO2 |
| 6(b)(ii) | rate $= k\ [CH_3COCH_3]\ [H^+]$<br>$1.60 \times 10^{-3} = k \times 0.30 \times 0.15$<br>$1.60 \times 10^{-3} / 0.045 = 0.0356$<br>$mol\,dm^3s^{-1}$ | Allow any row of data<br>Allow any answer that rounds to 0.036 | 1<br>1<br>1<br>1 | 5.1.1<br>AO2<br>MS0.0,2.2 |
| 6(c)(i) | (see table below)<br><br>ln$k$ on the $y$-axis + 1/T on $x$-axis<br>Sensible scales<br>Plots points correctly ± one square<br>Line of best fit correctly drawn | | 2<br><br><br><br>1<br>1<br>1<br>1 | 5.1.1<br>AO3<br>MS 3.1 |
| 6(c)(ii) | Shows triangle<br>Gradient = −5690 +/− 200<br>$-E_a/R = -5690$<br>$E_a = 5690 \times 8.31 = 47\,283\ J\ mol^{-1}$<br>$E_a = 47\ kJ\ mol^{-1}$ | Must include evidence that gradient is from a triangle made from the line and not just taken from two points | 1<br>1<br><br>1<br>1 | 5.1.1<br>AO3<br>MS3.3,3.4,3.5 |

Table for 6(c)(i):

| T/K | 1/T /K$^{-1}$ | Rate constant, $k$ | ln$k$ |
|---|---|---|---|
| 293 | $3.413 \times 10^{-3}$ | 0.0030 | −5.81 |
| 313 | $3.195 \times 10^{-3}$ | 0.0216 | −3.84 |
| 333 | $3.003 \times 10^{-3}$ | 0.122 | −2.10 |
| 353 | $2.883 \times 10^{-3}$ | 0.567 | −0.57 |

| Question | Answers | Extra information | Mark | AO Spec reference |
|---|---|---|---|---|
| **7(a)(i)** | $SO_3 = 3.0$ <br> $O_2 = 0.5$ | | 1 <br> 1 | 5.1.2 <br> AO2 |
| **7(a)(ii)** | $K_p = \dfrac{p^2_{SO_3}}{p^2_{SO_2} \times p_{O_2}}$ <br> Mole fractions <br> $SO_2 = 0.8/4.3 = 0.186$ <br> $O_2 = 0.5/4.3 = 0.116$ <br> $SO_3 = 3.0/4.3 = 0.698$ <br> Partial pressures <br> $SO_2 = 0.186 \times 210 = 39.06$ <br> $O_2 = 0.116 \times 210 = 24.36$ <br> $SO_3 = 0.698 \times 210 = 146.58$ <br> $K_p = \dfrac{146.58^2}{39.06^2 \times 24.36} = 0.578$ <br> $kPa^{-1}$ | | 1 <br> 1 <br><br> 1 <br><br><br><br> 1 <br><br> 1 | 5.1.2 <br> AO2 <br> MS2.2,2.3 |
| **7(a)(iii)** | Equilibrium would shift left/towards reactants <br> To oppose the change | Allow 'due to le Chatelier's principle' | 1 <br> 1 <br> 1 | 5.1.2 <br> AO3 |
| **7(a)(iv)** | $K_p$ would increase <br> Equilibrium would shift right/ towards exothermic <br> To oppose the change | Allow 'due to le Chatelier's principle' | 1 <br> 1 <br> 1 | 5.1.2 <br> AO3 |
| **7(b)** | 1/0.578 = <br><br> 1.73 kPa | E.c.f. from **7(a)(ii)** <br><br> Must be 3 s.f. <br> answer and unit score 2 marks independent of approach taken | 1 <br><br> 1 | 5.1.2 <br> AO2 |

| Question | Answers | Extra information | Mark | AO Spec reference |
|---|---|---|---|---|
| 8(a)(i) | Moles sulfuryl chloride start = 2.7/134.1 = 0.02<br><br>Moles sulfuryl chloride change = 0.67/134.1= 0.005<br><br>Moles at equilibrium<br>$SO_2Cl_2$ = 0.015 (mol)<br>$SO_2$ = 0.005 (mol)<br>$Cl_2$= 0.005 (mol) | | 1<br><br>1<br><br><br>1 | 5.1.2<br>AO2 |
| 8(a)(ii) | $K_p = \dfrac{p_{SO_2} \times p_{Cl_2}}{p_{SO_2Cl_2}}$<br>Mole fraction<br>$SO_2Cl_2$ = 0.015/0.025 = 0.6<br>$SO_2$ = 0.005/0.025 = 0.2<br>$Cl_2$ = 0.005/0.025 =0.2<br><br>Partial pressure =<br>$SO_2Cl_2$ = 0.6 × 125 = 75<br>$SO_2$ = 0.2 × 125 = 25<br>$Cl_2$ = 0.2 × 125 = 25<br>$K_p = \dfrac{25 \times 25}{75}$ = 8.33<br>kPa | | 1<br><br>1<br><br><br>1<br><br><br>1<br>1 | 5.1.2<br>AO2<br>MS2.2,2.3 |
| 8(b) | Tetrahedral shape drawn<br>With double bonds to oxygen<br>Bond angle 104-109.5 | Either draw with wedge and dotted lines or named | 1<br>1<br>1 | 2.2.2<br>AO1 |

**Skills box answers:**

a)

| Temp (°C) | time (s) | Temp (K) | $T^{-1}$ / K$^{-1}$ | $\left(\dfrac{1}{\text{time}}\right)$ |
|---|---|---|---|---|
| 20 | 88 | 293 | $3.41\times10^{-3}$ | −4.48 |
| 30 | 52 | 303 | $3.30\times10^{-3}$ | −3.95 |
| 40 | 32 | 313 | $3.19\times10^{-3}$ | −3.47 |
| 50 | 20 | 323 | $3.10\times10^{-3}$ | −3.00 |
| 60 | 13 | 333 | $3.00\times10^{-3}$ | −2.56 |

b)



c) Gradient = −4640 K (allow −4180 – 5100)

d) Gradient = $-\dfrac{E_a}{R} \therefore E_a = -R \times$ gradient = $-8.31 \times 4640$ = 38 560 J mol$^{-1}$

$\therefore E_a$ = 38.5 kJ mol$^{-1}$
(If ± 5% is allowed in the gradient, then the $E_a$ would be between 36.6 to 40.4 kJ mol$^{-1}$)